grandeur is increased. He is then led to entertain broader views of Nature and to see more clearly the relations of part to part. Finally he is led to a proper appreciation of his place in nature; possibly he is humbled by the certainty of his individual insignificance in the vast organism, but he is strengthened by the equal certainty that in his race he is the inheritor of all that makes for progress and advancement.

Men of this department of Natural Science Instruction, shall we not make of science a help to higher culture, rather than an aid to more material success? Let us give it wings, so that it may carry our pupils above mere earthly things, and not doom it to do no more than turn our spindles, haul our goods and coin our money. While we rejoice in these material achievements of science, let us bear in mind that these are not of supreme importance. When we stand by the mighty Niagara we realize that it has an infinitely higher significance for man than the mere turning of wheels. Just as the solemn flood of water speaks to and stirs man's deeper thoughts, and makes him forget the wheel-turning power of the rushing torrent, so the profound contemplation of nature through enlightened and untrammeled science leads him away from sordid things up to the higher planes of thought and experience.

Chas. E. Bessey.

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*THE HUMANISTIC ELEMENT IN SCIENCE.**

The time has happily passed when the rival supporters of literary studies on the one hand and of scientific studies on the other slept on their arms or engaged in open combat. Both sides were intent on victory, with no disposition to give quarter or to concede that the truth might not all be on one side. But when opponents have come to know each other better they not infrequently abide by at least a tacit agreement to live as friends. We have now arrived at such a stage in educational history and practice. An occasional note of discord still comes from the few who refuse to be reconstructed; but the prominent figures in the old conflict are fast passing over to the majority, and the new generation is born with a more pacific spirit. The pursuits of peace are more liberalizing than the devastations of war. Hence the origin at first of a spirit of toleration, and then of equality and fraternity. It is now time to inquire about a common ancestry and community of aims and interests. The spirit of the times does not sanction narrow bigotry or unseemly dissension. Educational intolerance is now as much an anachronism as religious intolerance or martyrdom for conscience. It has come to be recognized that no one system of theology contains all the truth, and no one branch of human learning is the sole instrument of culture, nor does it possess the exclusive capacity of imparting power.

At the time of the revival of learning in the Middle Ages the apostles of the Renaissance, who introduced the study of classical literature, were called humanists. Hence humanism has often been called 'the culture derived from classical training.' But more broadly, humanism is a system of thought in which the human element or interest predominates. The humanities therefore include much more than classical language and literature. They stand for philology, poetry, rhetoric, grammar and archæology, as well as for the Greek and Roman classics. Philological studies, says G. P. Marsh, "were called *literæ humaniores*, the humanities, by way of opposition to the *literæ divinæ*, or divinity, the two studies, philology and theology, then completing the circle of scholastic knowledge, which, at the period of the introduction of the phrase, scarcely included any branch of

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physical science." The humanities were not so named because of their peculiar value in producing culture, nor because of the human interests which they fostered, but because they were human or secular in their nature, as contrasted with the theological or divine.

Ever since the revival of learning, philology and polite literature have been justly held in high esteem as instruments of culture and as 'the literature of power.' Generation after generation of English scholars and statesmen have received their intellectual training largely by means of mathematics and the classical languages. In modern times there have been added to these, subsequent to University residence, the acquisition of modern tongues and extensive foreign travel. In America the classics have furnished the major part of a liberal training to many successive classes of students. It is only within the past twenty-five years that science has come to form any considerable part of the curriculum of American colleges. It is not my purpose to detract in any way from the utility and value of literature, philology, and philosophy as important components of a liberal education, but rather to show what the study of science has in common with the humanities as liberally interpreted by the broadest scholars. A high estimate has rightly been put upon the study of the humanities by the most prominent educators, and it is not necessary to undervalue their judgment for the purpose of advancing the cause of science. Whatever antipathy or opposition science has encountered has had its origin either in prejudice or in a lack of understanding of the aims, the nature and the content of any connected body of science. It is perhaps folly to try to remove the former, but a more refreshing task to point out what human interests are involved in the pursuit of science, and to what higher ministry to man's intellectual and ethical needs it has been applied.

It may be well at the outset to clear away a misconception relating to the objects in view in scientific study and investigation. It is a gross libel on scientific men to assert that the chief end aimed at in the pursuit of science and the claims most strongly urged in advocacy of its cultivation are narrowly utilitarian or intensely practical. If worldly success were the only reward awaiting the scientific investigator, but few branches of science would be fortunate enough to find their votaries. The taste for scientific research is a passion which finds its gratification in the truth it seeks. It can never be satisfied to con over the lessons of the past alone, but it restlessly pushes on into new chapters. The true scientific man recognizes the immense value of literary and linguistic study; he is also aware of the fact that the human intellect is many-sided and has numerous aptitudes. To be broadly developed, to have liberal sympathies, and to acquire the power to be master of circumtances, the educated man of to-day must know not only language and literature and history and philosophy; but he must have knowledge of his environment, of the physical laws under which he lives, of the varied life about him, of the earth which he inhabits, and of the heavens spread out in magnificent panorama above him.

Languages are considered to be the humanistic studies *par excellence* because they are the product of human endeavor, the outgrowth of human thought, the chief exponent and index of evolution in the human mind. All language is therefore entitled to be included in the humanities. But all languages are not of equal interest and value. They are not all equally developed products, not all equally differentiated flowers of the human intellect. The greatest interest attaches to the language of

those people who have attained to the highest civilization; whose art, architecture, industries, literature and learning have reached the highest development; whose works, in short, possess the highest finish as the expression of human thought.

An important distinction may be made among the subjects belonging in the narrower sense to the humanities. Language in its structure may be regarded as the involuntary product of human activity, the result of the unconscious struggle of the mind, its reaction against the environment, with the result of a definite attainment not aimed at. The results are not fortuitous, because all activity is under law. Whether the effort is conscious or unconscious, the result anticipated or unexpected, it must issue in accordance with the laws controlling human action. On the other hand, art, architecture and poetry are the conscious products of thought. They are the results of struggles after definite and well conceived ends. They are the issue of an inner impulsion toward an ideal attainment. They are not so much the finality of collective effort as the offspring of individual genius. The written language, the canvas and colors, the quarried marble and granite, are the materials with which art works and out of which it constructs a poem, a painting, a statue, or a temple. They are compelled by poetic and artistic genius to shadow forth the ideals existing in the mind of the poet and the artist. The pigments and the marble are not art. It is the artistic use of language, of canvas and of marble that require the skill of the master. Then too the pen of the poet, the brush of the painter, and the chisel of the sculptor touch their highest point when they delineate that which is truest in life and nature, softened with ideality and ennobled by aspiration.

Now what characteristics has science that ally it to literature and art? What have they in common which entitles science to be treated as one of the humanities?

In the first place the materials which science uses are her own. It is this fact which differentiates science from other branches of learning. But given the materials, the operations of the human mind in working on them are kindred in character and similar in result to those of the same order of intellect elsewhere. It is an unworthy conception of science that makes it consist in the collection of facts about the material world or even the higher animal life. These materials, it is true, must be collected, just as the pigments must be ground and the marble and granite must be quarried. But he who stops with the collection of facts is doing the lowest order of work in science. He contributes to the final result, but it requires genius to clear away the rubbish and to construct the temple of science out of the scattered materials. Or better still, the genius in science does not merely hew and shape and color, but he brings together the *disjuncta membra* formed by the hand of the Almighty, and reconstructs a beautiful body fit for the Creator to look upon. The most important element in science is the human element, that which vivifies the dead facts, fuses them with the fire of imagination, beautifies with the fine finish of ideality, and constructs an articulated system which must conform to the truth. Science is then in a very large sense a product of human thought, the result of human endeavor. A body of correlated scientific truth can hardly be studied apart from the personality of the names inseparably linked with it. It is scarcely less a human interest which draws us to it than that which attaches to language as the instrument of human expression. Indeed the former has the added attraction of distinct personalities. It is the personality of a few master minds working with creative ability, impressing their

own thought upon science, and marshalling facts in great divisions which embody their ideas of the order and dependencies of nature.

It is no new thought that scientific study makes a draft upon the imagination. This aspect of science allies it to art and literature. Music and mathematics have not infrequently been congeners in the same gifted genius, and mathematics is becoming an indispensable adjunct to every branch of science. Maxwell, perhaps the greatest modern physicist, often indulged in poetic composition, and his poetry was of no mean order. It may be readily granted that the scientific imagination is cultivated and strengthened by exercise in the related realm of poetry. The intricate and fascinating subject of electricity is greatly indebted to the imaginative faculty of the great discoverers in this field. It is an unfruitful science that has not been enriched by the scientific imagination.

In another respect science fosters human and ethical interests. It compels the restless struggle after ideals. It holds up an ideal condition which is the goal of its ambition, the one thing which it must attain before it can rest content. Hence the scientific worker studies sources of error and seeks to eliminate them. By repeated attacks he approaches nearer and nearer to the citadel which he tries to capture. And after all is done he recognizes that the object of his endeavor has not been fully attained. It is much like the chase after the foot of the rainbow, which ever moves onward as it is pursued. Says Huxley: "Men are said to be partial judges of themselves. * * * Life seems terribly foreshortened as they look back, and the mountain they set themselves to climb in youth turns out to be a mere spur of immeasurably higher ranges when with failing breath they reach the top." But it is infinitely better to have reached the top of a spur even than never to have begun the ascent. The whole world has been called to a broader outlook and a grander vision by those who have reached the spurs and higher ranges. Their effort after ideals ennobles and humbles. It chastens while it subdues.

In some respects science is more humanistic than the humanities. Here and there ancient literature enforces the conception of the reign of law. It presents the human captive vainly prolonging the struggle to escape it. Tantalus-like, the unattainable ever eludes the seeker. Prometheus bound is a fit symbol of circumscribed humanity. The same thought, which has always impressed itself upon the race and worn itself deep into human experience, is enforced in Holy Writ: "If I take the wings of the morning, and dwell in the uttermost parts of the sea; even there shall thy hand lead and thy right hand hold me."

Now science illustrates and emphasizes the reign of law. It has cleared away the mystical, the fortuituous, the anthropological, and has given us instead the orderly and progressive sequences of natural phenomena. It has in no way weakened the necessity felt for a First Cause, but it presents the activity of that Cause under a new and more rational aspect. It presents a Creator who sees the end from the beginning, who does not need to hold the world in leash or drive it with a goad, but who endowed matter with certain capabilities and infused into it divine energy, so that it can run its ceaseless changes down the grooves of time. Science has replaced a world of humanistic divinities by a world of energy and law. Instead of the caprice of classical gods and goddesses, it has supplied a physical organism devised and elaborated by infinite wisdom. Man has therefore learned to order his physical life so as to conform to the laws of the physical world, or if he elects to transgress those laws he does not expect the interposition

of humanistic divinities to effect his escape. So impressed is the human mind by the reign of law in the physical world that it has carried this conception over into the spiritual. 'Natural law in the spiritual world' is an obvious sequence of natural law in the physical world. It is therefore an intensely human interest that impels to the study of the reign of law.

Every great branch of learning has been adorned with the names of eminent scholars and discoverers. When we bear in mind that the arts and sciences are the product of directed, conscious human effort, and that it is the lot of but few to be endowed with the intellectual insight, the native sagacity, the penetrating perception to push far beyond their fellows, we are not surprised at the smallness of the number of luminous names that shine on the rolls of honor, or that go down to succeeding generations as the great discoverers. The human interest in these names, differentiated from all others by their powers and their contributions to the progress of the world, is equally intense whether they belong to art or architecture, to literature or science. To these men it has been given to delight the soul with beauty, to penetrate the unknown, to enlarge the boundaries of human knowledge, and to gather up the tangled threads of thought and weave them into a tapestry of beautiful design. Each department of creative art or of learning is justly proud of the distinguished names associated with it. They all inspire the same human interest and are characterized by the same passionate devotion. Galileo, persecuted and condemned for his scientific writings, is still a vivid figure, a living personage in history; and we look with reverence upon the old bronze lamp or candelabra, swinging on its long suspending rope in the Duomo at Pisa, as it swung centuries ago when Galileo watched it and discovered the isochronism of its pendular motions. Old Copernicus, turning over with death-stricken hands the first copy of his book on the solar system, which he dared not publish sooner, is a figure to excite at the same time sympathy and indignation. The genius of Michael Angelo still presides over the art and architecture of Rome, and Raphael will forever stand beside the glowing canvas of the Sistine Madonna, which burns itself into the soul of every beholder. One almost expects to see Scott standing within the deep shadows of Melrose Abbey by moonlight, or strolling with his faithful hounds in the woods about Abbotsford. Alloway Kirk and the Brig o'Doon are still visited by the strange creations of the busy brain of Burns. How sweetly the chimes of Holy Trinity Church ring out over the hills about Stratford-on-Avon on a quiet evening! Green are the fields and quiet the cottagers along the cleanly lanes and alleys where the great poet was born. In the spacious chimney corner of the Hathaway cottage linger the shades of Ann Hathaway and William Shakespeare. It is hard to believe that for 300 years the ashes of Shakespeare have reposed beneath the slab in Holy Trinity, guarded by the famous couplet,

> "Blest be the man that spares these stones
> And curst be he that moves my bones."

The scientific traveller in London turns his steps toward the Royal Institution in Albermarle street, where the noble Faraday worked and achieved immortal renown. There are the coils and magnets and other appliances which his own hands fashioned; and Faraday himself is everywhere present there. How powerful still is the memory of our own Joseph Henry at Princeton and Washington! Though he be dead, his works do follow him.

Prof. Butler said in his address at Denver: "We must enlarge our conception of the humanities, for humanity is broader and deeper than we have hitherto suspected.

It touches the universe at many more points than one; and, properly interpreted, the study of nature may be classed among the humanities as truly as the study of language itself. This conclusion, which would welcome science with open arms into the school and utilize its opportunities and advantages at every stage of education, does not mean that all studies are of equal educational value or that they are naturally and indifferently interchangeable, as are the parts of some machines. It means rather that the study of nature is entitled to recognition on grounds similar to those put forward for the study of literature of art, and of history." This position concedes the claim which I am now urging. It is an ancient chapter in educational history that places the humanities in one grand division and the sciences in another, without mutual relations or common aims and interests. The relative value of these subjects as educational material I am not now disposed to discuss, passing it with the remark that the order of excellence laid down will depend upon the standard of values assumed and the point of view of the writer.

It will not be inappropriate to make special reference to the study of physics in connection with the subject of this address. No one of the sciences is associated with a longer list of splendid names; none appeals more strongly to that characteristic of the human mind which searches into the causes of phenomena; none is more capable of serving directly human needs and of advancing the material interests of society.

It is almost the universal judgment that physics is a fundamental subject, and more than any other is essential to the pursuit of other branches of science. In its historical development it is no less ancient and honorable than chemistry, while in recent times the proof that it has lost none of its vigor lies in the splendid discoveries that are almost unrivaled in any other department of scientific investigation.

It is therefore justifiable to urge that physics be made an essential part of every course of study in secondary schools, and that the place and time devoted to it correspond to its importance. It is not enough that physics be admitted to all secondary schools, but that it should not be there in a secondary place. It should be placed on an equal footing with the most favored subjects. It seeks no preferences, but is strenuous that no special bounties be extended to other branches. Whether it be considered from the point of view of its educational value, of its splendid achievements and its service to civilization, or of the interest that it awakens in the unfolding mind of the inquiring student, it should form as essential a part of every course of study as mathematics or history or language. First of all, a student should know his own language; it does not admit of question that he should also know the historical development of his own country; he should in addition be familiar with the fundamental physical principles and concepts which are as closely interwoven with his life and well-being as are his language and the history of the land in which he lives.

If now the pursuit of this noble science is to serve the human and ethical interests which we are contemplating, it is essential that its serious study be entered upon at the right period in the education of the pupil. It is very properly pointed out by Mr. Gage in the report of the Conference of Ten on Physics and Chemistry that "Physics requires the largest knowledge of mathematics that the secondary school affords, and the difficulty of this study demands the greatest maturity of mind." What interest can be served by placing it in the first year of the high school, except

its subordination to more favored branches, it is quite impossible to understand. The Conference of Ten recommended "That physics be pursued the last year of the high school course." That recommendation meets the enthusiastic approval of every physics teacher whose experience is worth considering. The exigencies of the school programme sometimes require that physics be crowded down into the third year, but the instructor in this subject should never cease to protest against any further lowering of the standard by its relegation to the second year. When only a single year is sought for a subject of such transcendent importance, the studies that are crowded to the front for from three to six years should be compelled, in all fairness and reason, to give way, if necessary, at the point where the physics properly belongs. The pupil will then be provided with the requisite knowledge of geometry so essential to the intelligent study of physics, and may be presumed to have that maturity of mind which will enable him to profit by the study.

The limits of this paper do not permit me to enlarge on the method to be pursued in teaching physics. It must suffice to say that the student in the elements needs a text-book of principles for the purpose of securing accuracy and to enable him to dwell long enough on any portion to comprehend it. To the didactic work of the class room should be added the method of the laboratory. Practical work acts like a mordant to fix the color which may otherwise be evanescent. It is the testing machine to determine the strength and toughness of intellectual fibre. It furnishes a scale by which to evaluate acquisitions. It is the method of original investigation applied to the student; he will not discover any new laws of nature, but he will discover his own ignorance and limitations.

Henry S. Carhart.

*THE TEACHING OF BEGINNING CHEMISTRY.**

The momentous changes which have been brought about in chemical science within the past two decades are too often lost sight of in teaching the elements of the subject. It is easier to go in the old way, the habit of descriptive chemistry, founded primarily on the atomic hypothesis, is too well established to be suddenly uprooted, and, as a consequence, in America we can see but little progress toward a more rational and scientific means of beginning the study. The reason for this unsatisfactory condition is most probably to be found in the history of the development of science during the present century. Gay-Lussac, Dalton, Berzelius, Davy, Faraday, and the other lesser lights who appeared upon the chemical firmament between the years of 1800 and 1826, were completely engrossed with the discovery of new elements, the determination of chemical equivalents and the relationships between these latter quantities and the atomic weights. It was then that our system of chemical notation originated, and for this, even if his name were not inseparably connected with other lines of advance, we owe a lasting debt of gratitude to Berzelius. Naturally at this time, methods of analysis in inorganic chemistry, both qualitative and quantitative, assumed the greatest importance, for where the composition of so many new minerals remained to be ascertained, and when in each a possible new element might be discovered, such work must necessarily claim the attention of the foremost investigators. Scarcely an appeal was made to turn the science into broader channels, the material side was uppermost, the statics of chemistry was being investigated, and there was no time to think of the nature of chemical changes from any standpoint other than that of the transposition of matter. The

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